

# Myth buster

## Connection inspection and Cleaning

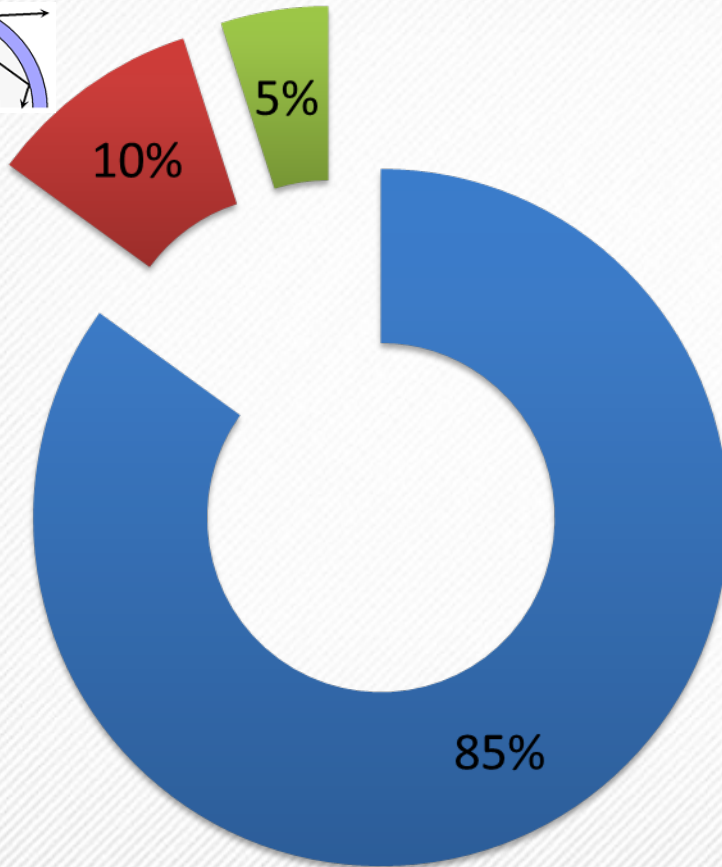
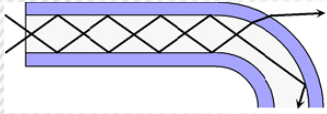
Gwenn AMICE  
Sr Applications engineer  
April 2014



# Installation best practices

Where are the troubles coming from?

> Connector cleanliness and macrobending



■ Dirty/damage optical connection

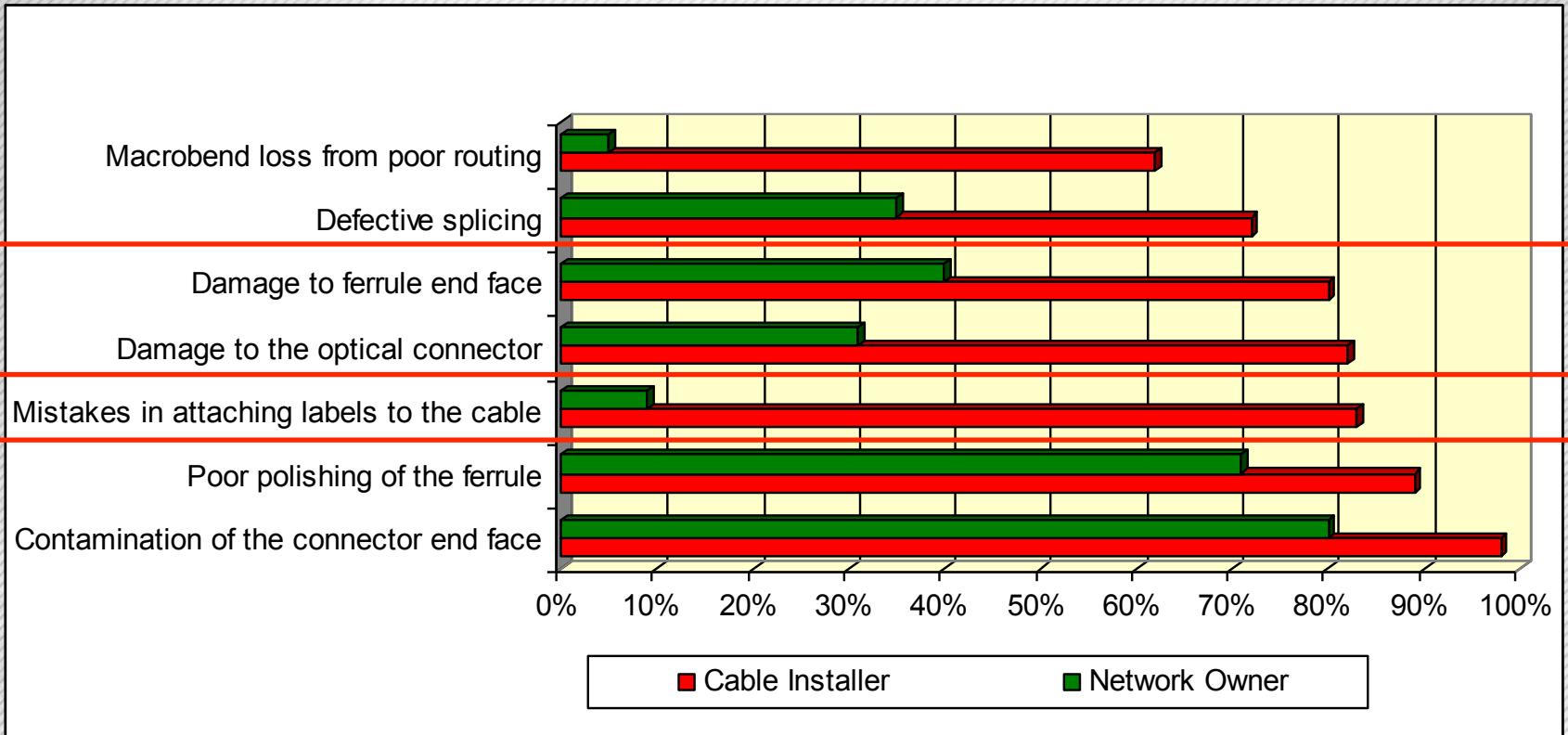
■ Macrobends

■ Other



Defective connector failing acceptance criteria.

# IMPACT OF BAD CONNECTORS

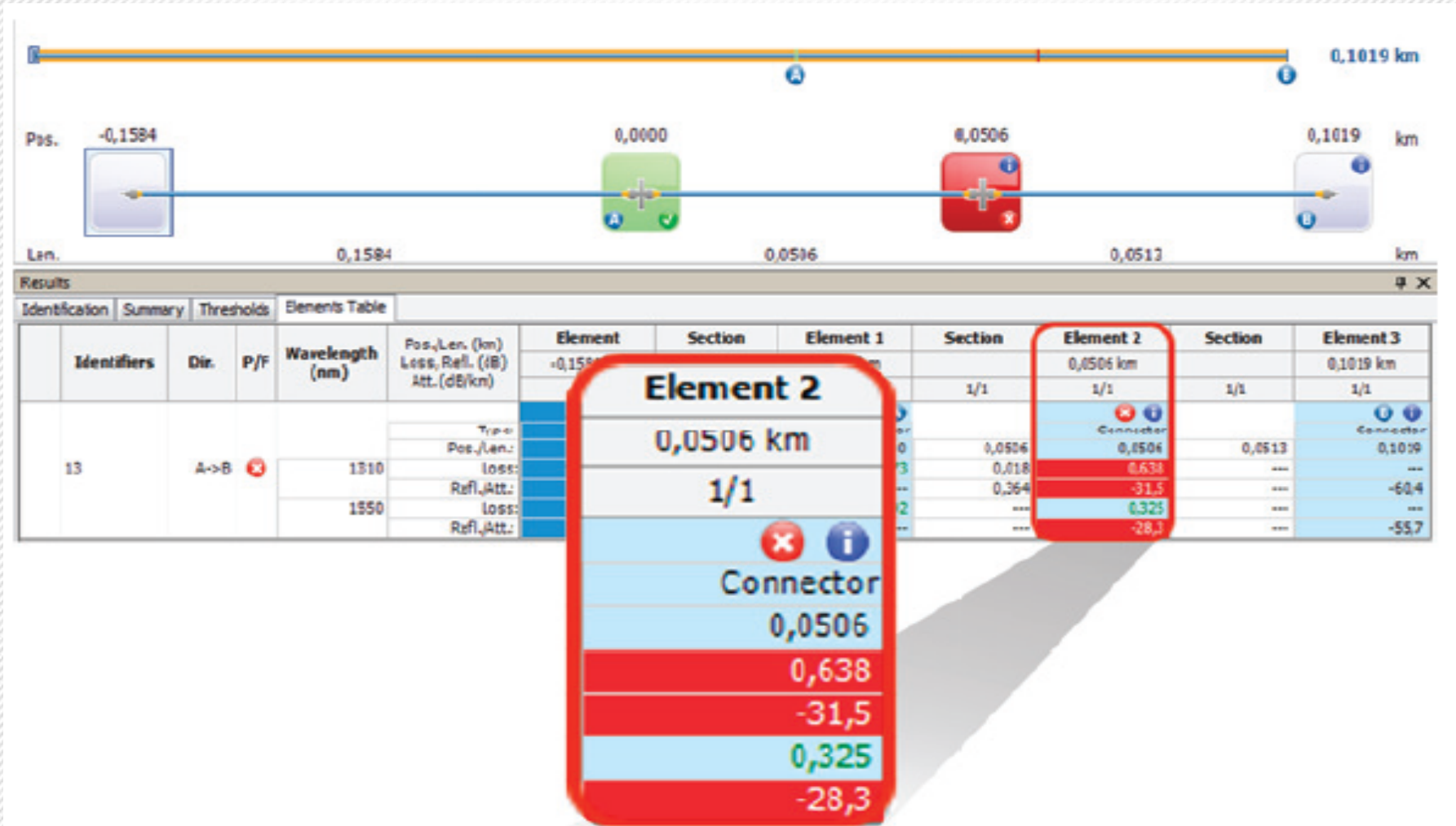


- The chart above is a summary of a study from **NTT-Advanced Technology** that polled network owner and cable installers on the sources of network failures
- **98%** of cable installers and **80%** of network owners answered “Yes” to having contamination be the root cause of a network failure.

# IMPACT OF BAD CONNECTORS

Connection fail the test before cleaning

- Contaminants in a connection will impact reflectance and loss

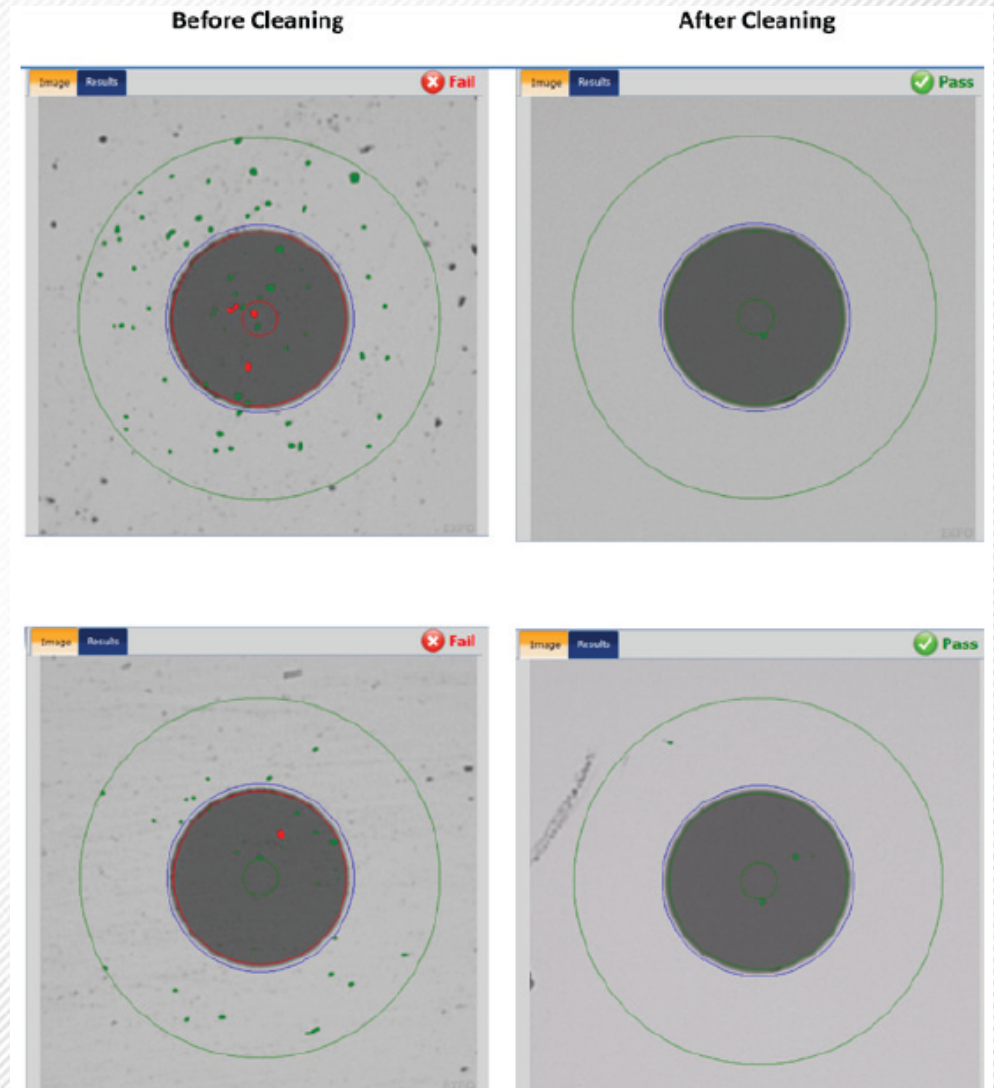
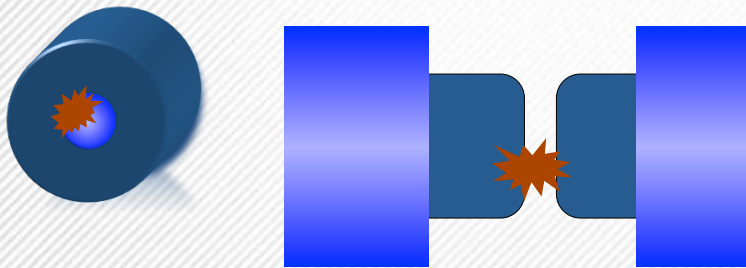
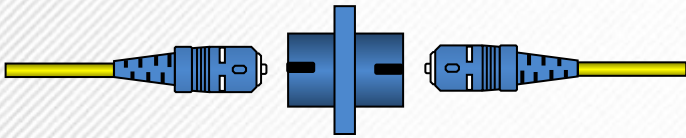




# IMPACT OF BAD CONNECTORS

## Inspection and cleaning

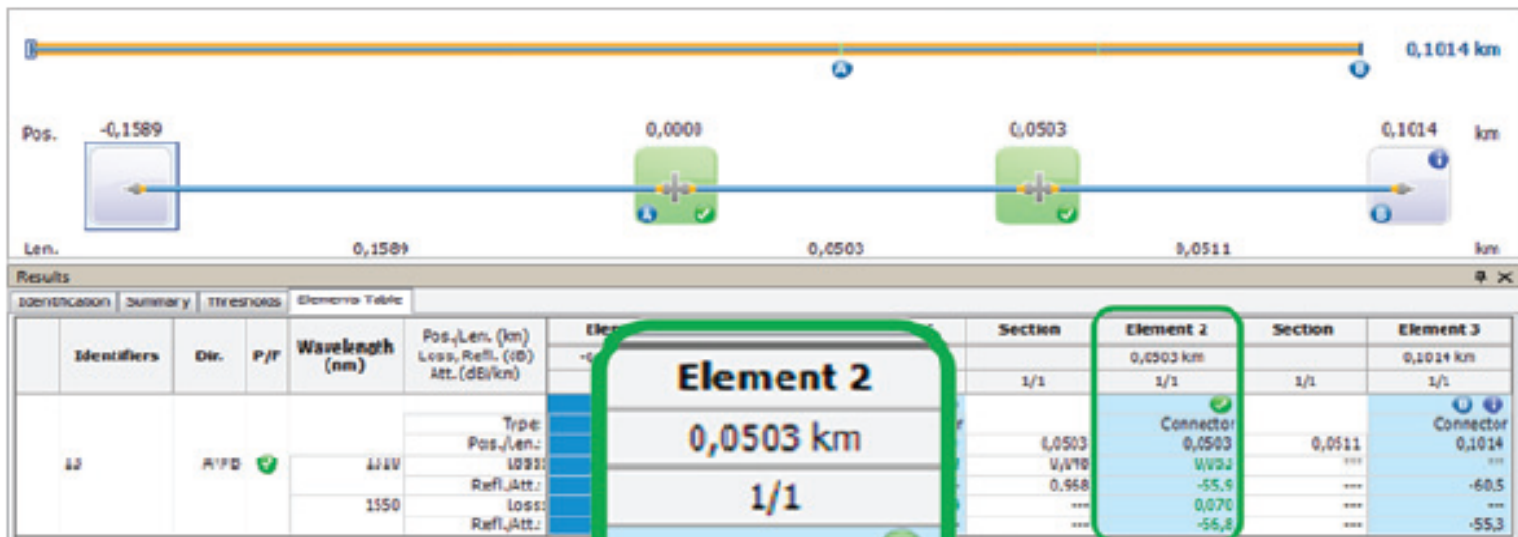
- › A connection is made of 2 connectors....
- › They should both be inspected and cleaned if needs be.



# IMPACT OF BAD CONNECTORS

Connection pass the test after cleaning

- › Acceptable values for loss at 1310/1550nm are :
  - › Less than 0.35dB / connection (industry average standard)
  - › Less than -50dB reflectance if UPC, less than -65dB if APC

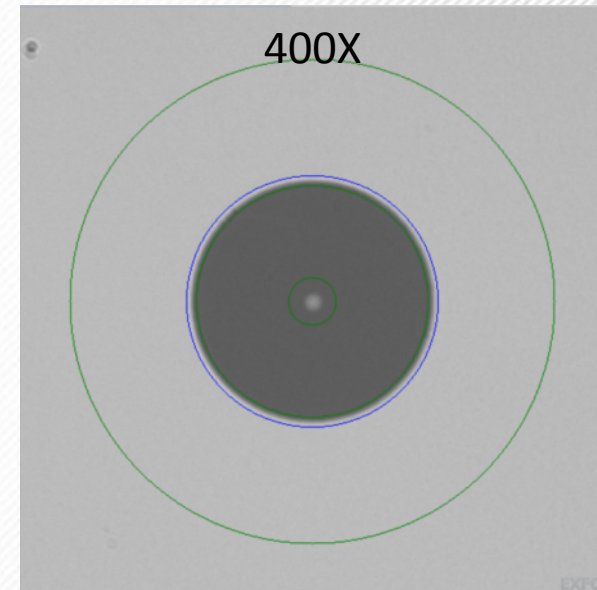
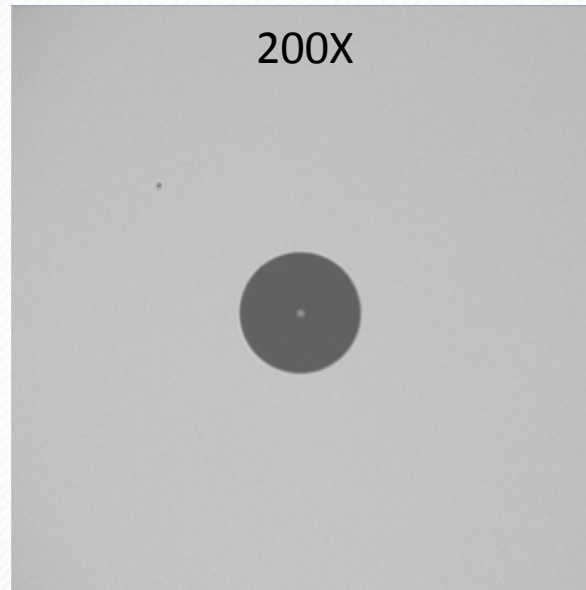
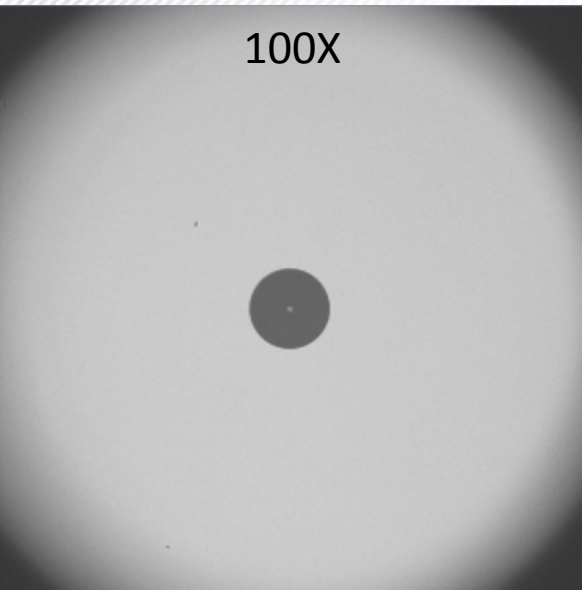




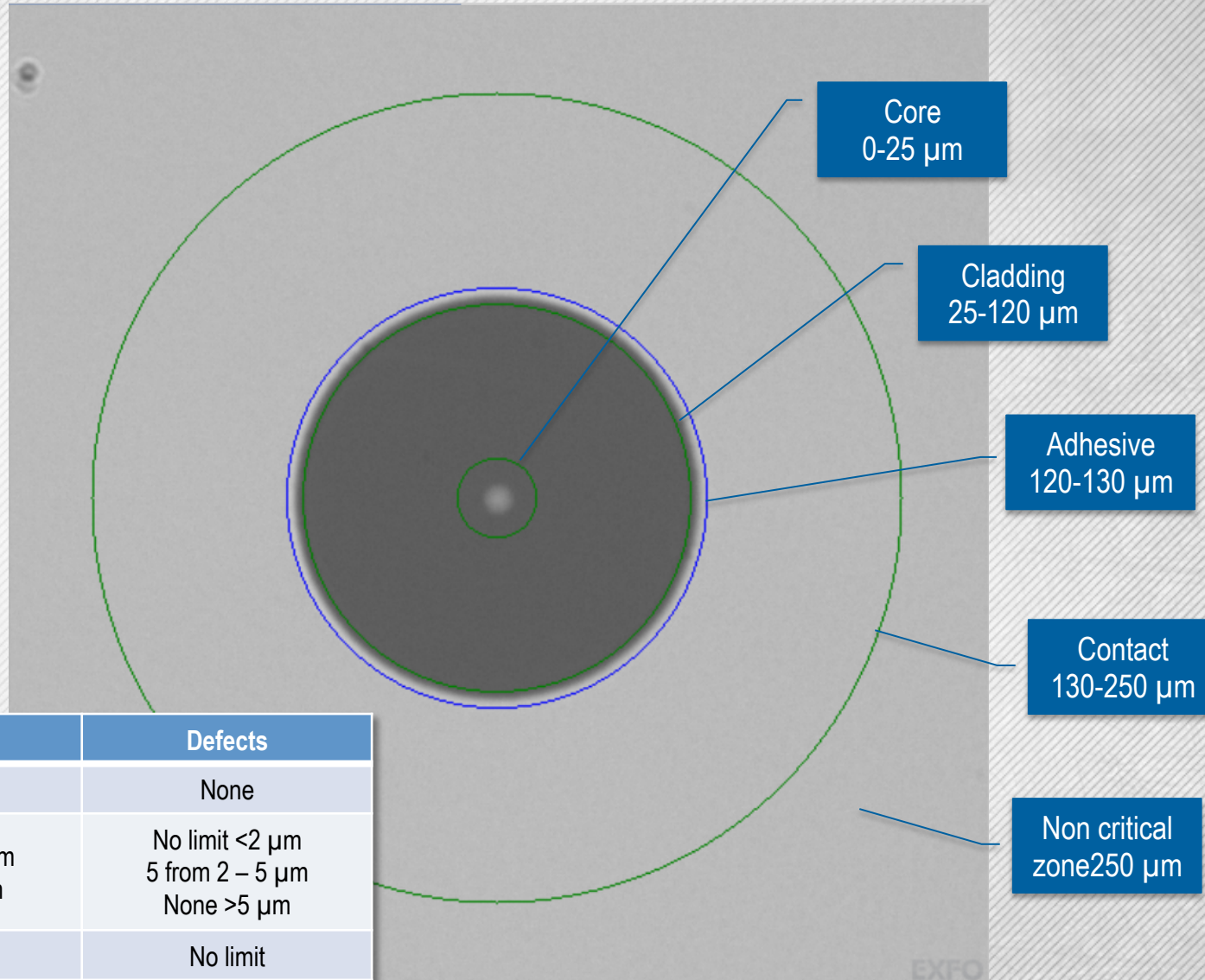
# Connector endface

## Single fiber connector

> 3 levels of magnifications to cover a larger surface



# Connector endface



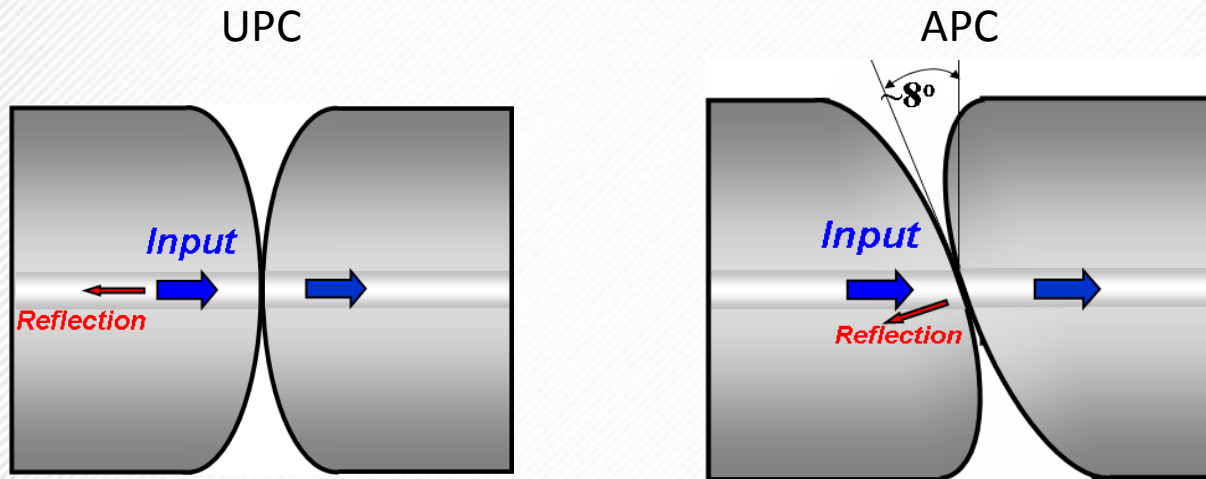
Zones	Scratches	Defects
A: Core	None	None
B: Cladding	No limit $\leq 3 \mu\text{m}$ None $> 3 \mu\text{m}$	No limit $< 2 \mu\text{m}$ 5 from 2 – 5 $\mu\text{m}$ None $> 5 \mu\text{m}$
C: Adhesive	No limit	No limit
D: Contact	No limit	None $\geq 10 \mu\text{m}$



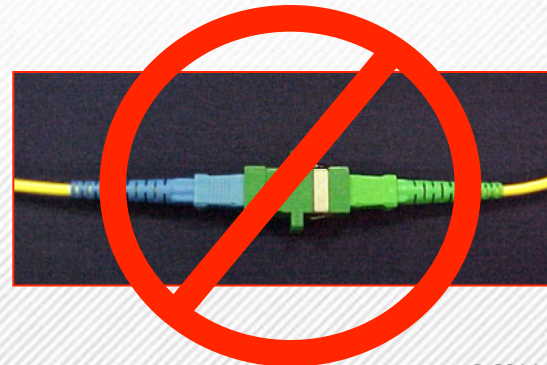
# Connector types

## Angle polished vs Flat polished connectors

- › In an optical connection there is always\* a reflectance
- › APC connectors are optimized for reflectance



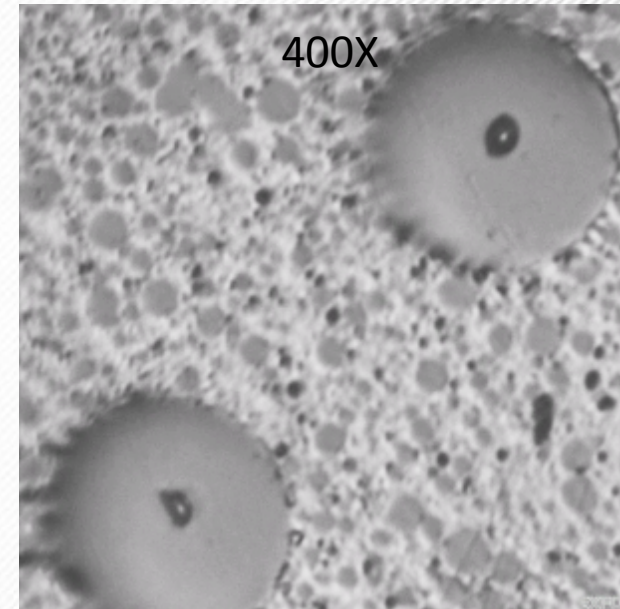
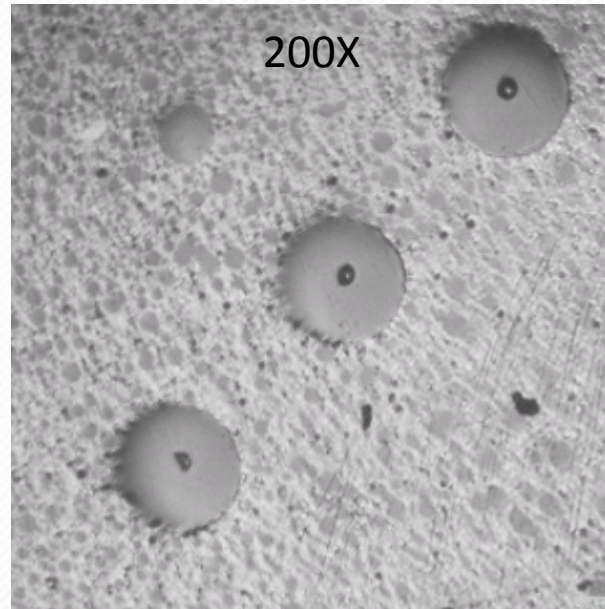
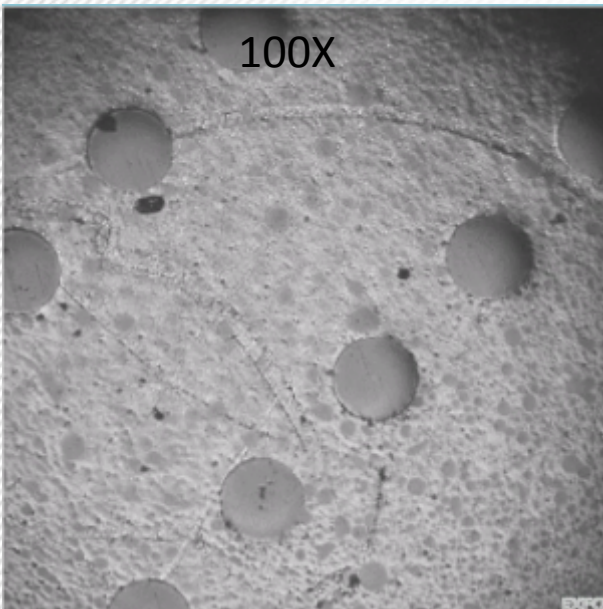
Never connect an APC to a UPC



# MPO Connector endface

Multiple fibers connector

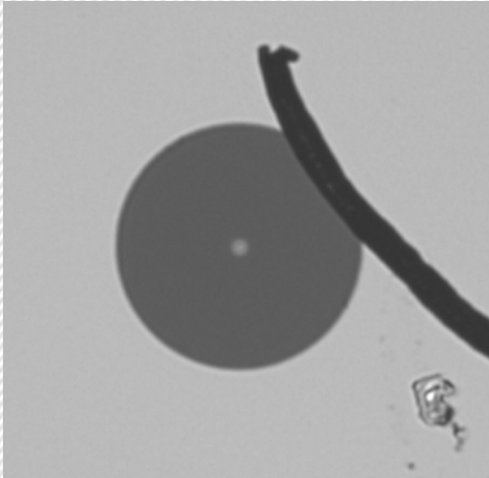
- › 3 levels of magnifications to cover a larger surface
- › MTP/MPO connectors are usually APC



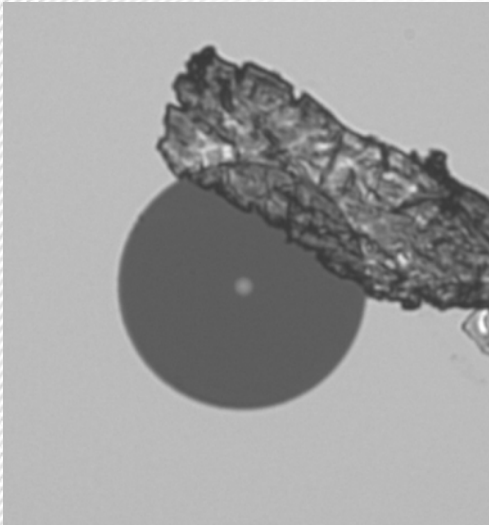


# Dust, spider legs.....

Before mating



After mating



- › Not the most common one but surely the most damageable to the connectors...
- › drywall, concrete, skin particles and sand are hard and solid contaminant that will:
  - › Limit the quality of mating resulting in misalignment and bad contact
  - › Permanently damage the connectors resulting in high reflectance and high loss.
- › Proper cleaning will remove the residue

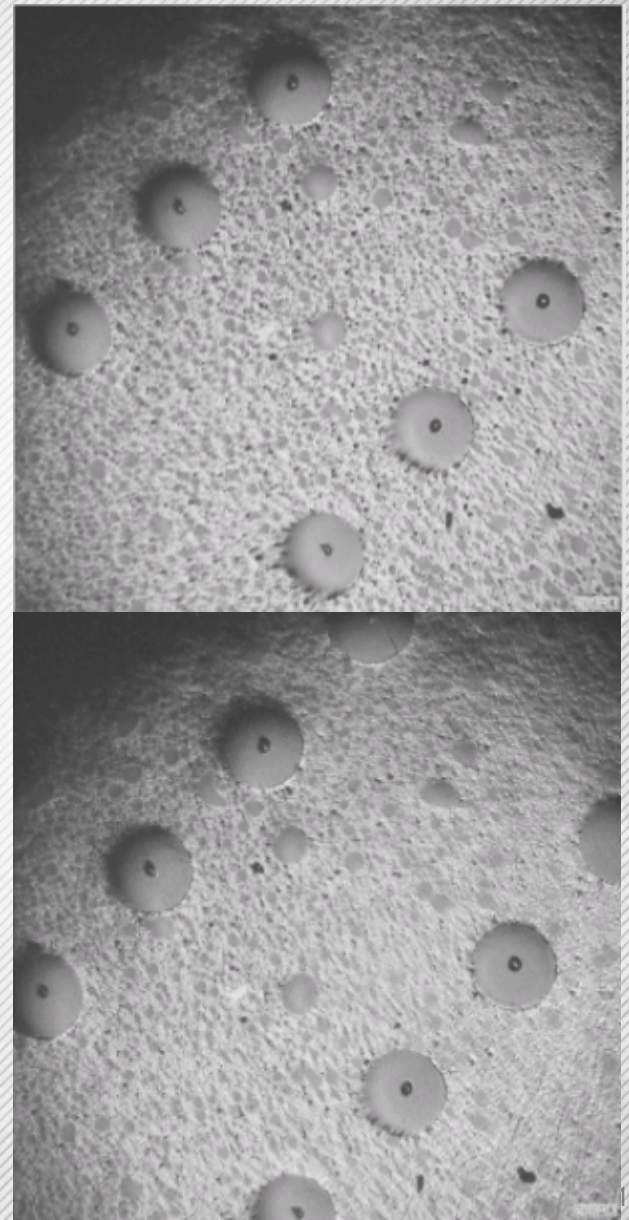
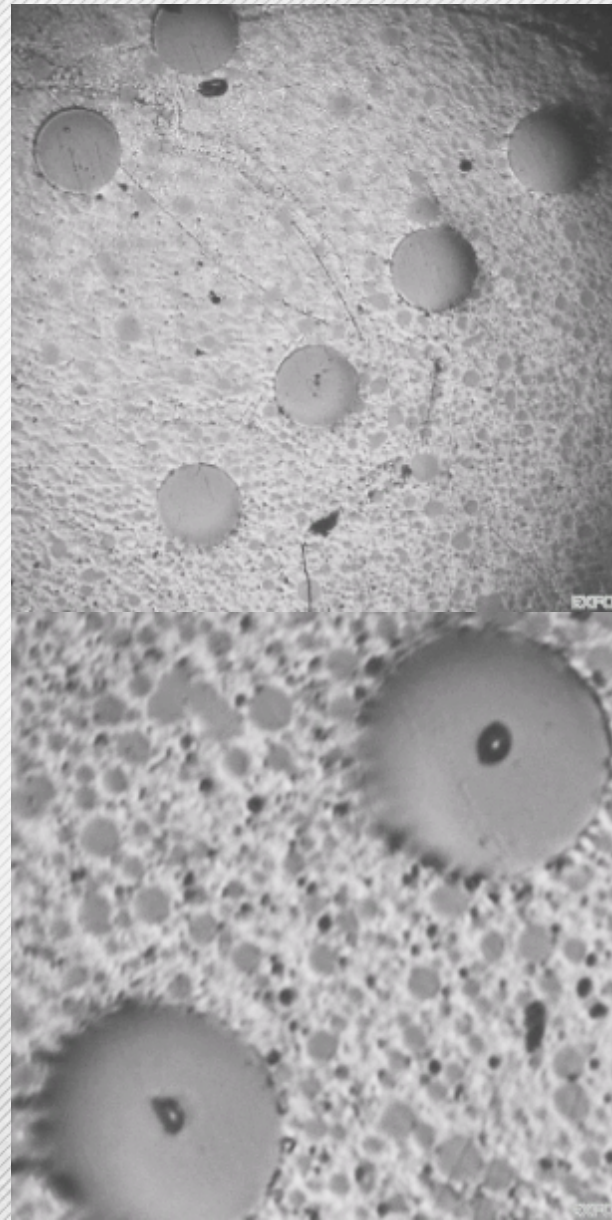
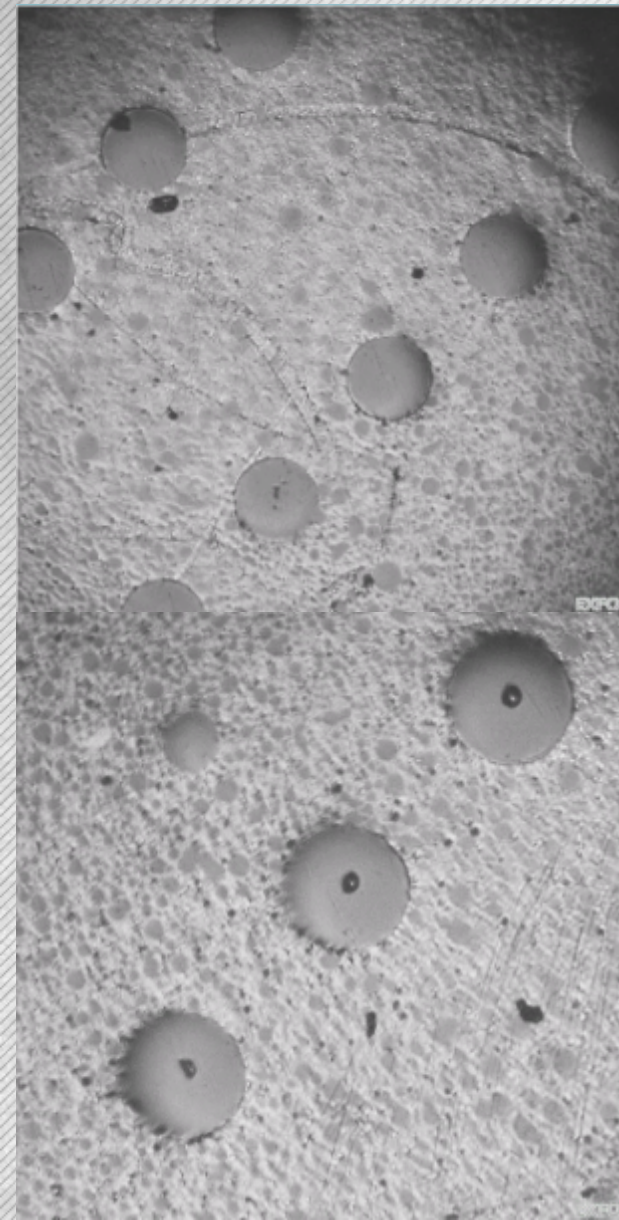
# Tight budget examples

## Datacenters and high speed interfaces

	IEEE	Designation	Mbit/s	Fiber Type	Number of fibers	Maximum link length (m)	Maximum channel insertion loss (dB)
10-Gbit Ethernet	802.3ae	10GBase-SR	10,000	OM3	2	300	2,6
40-Gbit Ethernet	P802.3ba	40GBase-SR4	40,000	OM3	8	100	1,9
40-Gbit Ethernet	P802.3ba	40GBase-SR4	40,000	OM4	8	150	1,5
100-Gbit Ethernet	P802.3ba	100GBase-SR10	100,000	OM3	20	100	1,9
100-Gbit Ethernet	P802.3ba	100GBase-SR10	100,000	OM4	20	150	1,5



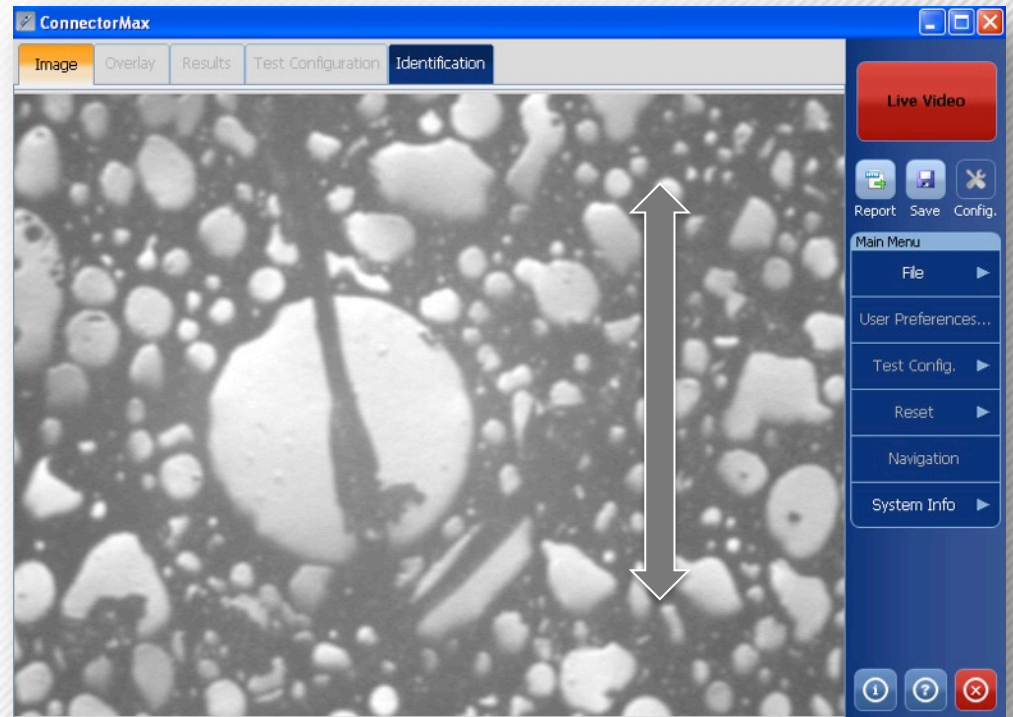
# Multi-fiber connector inspection





# Multifiber Inspection

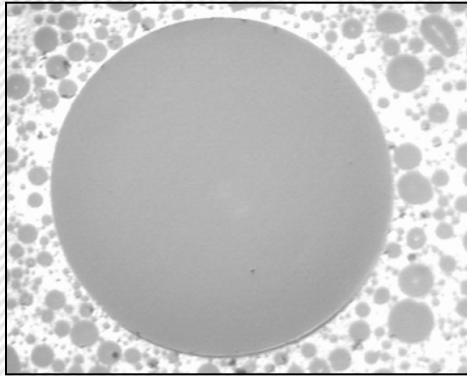
- › A scanning wheel allows to inspect each fiber
- › For multi-row connectors a X&Y axis adaptor is available



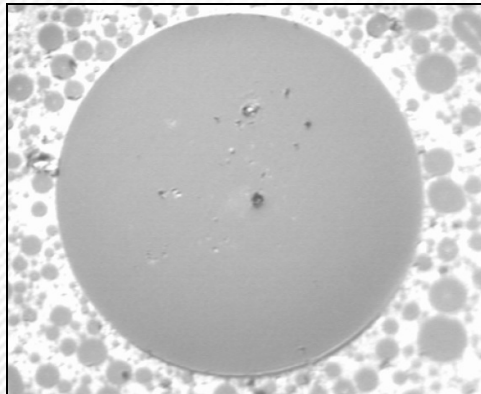
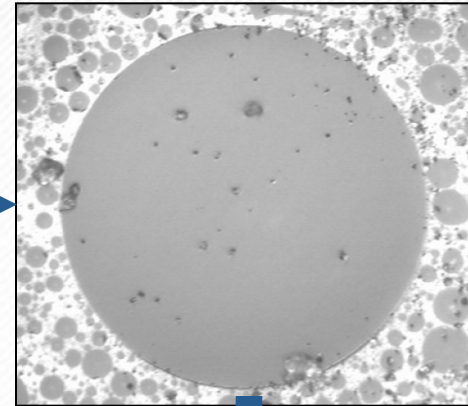


# Lasting Effects of Dust Contamination

Initial Clean End face



Contaminated End face



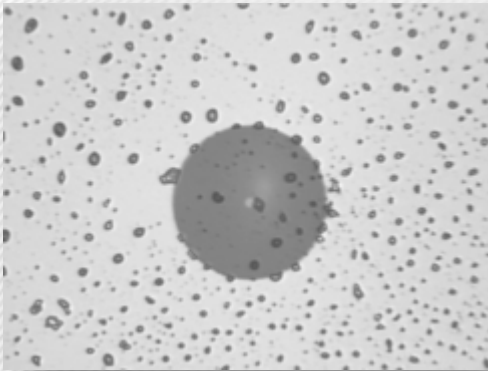
Mated 5 times dirty then cleaned  
results in severe permanent damage

# Residue Cross Contamination

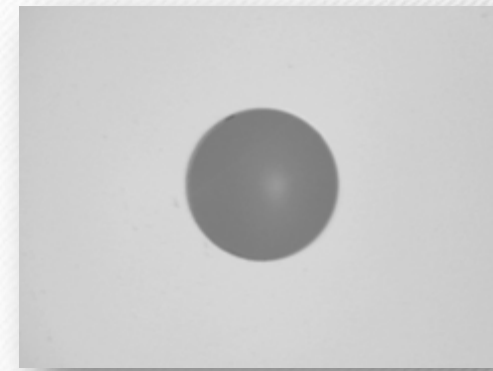
Dust/dirt residues transfer:

> If not cleaned properly residues will transfer when mating

Before mating:

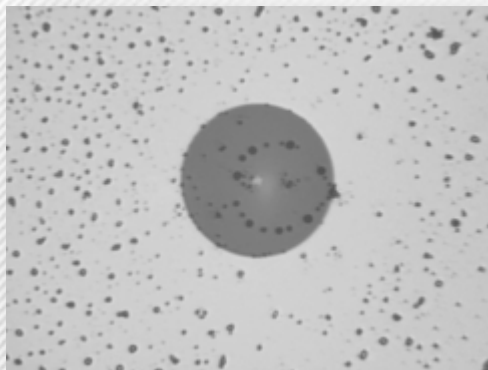


Connector A

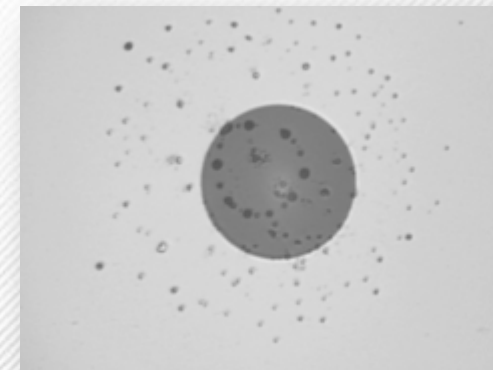
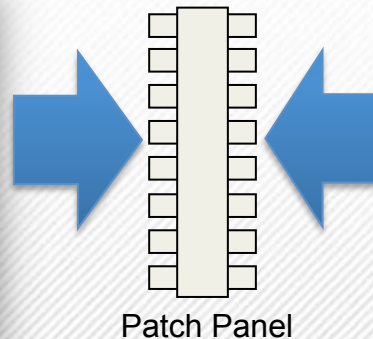


Connector B

After mating:



Connector A

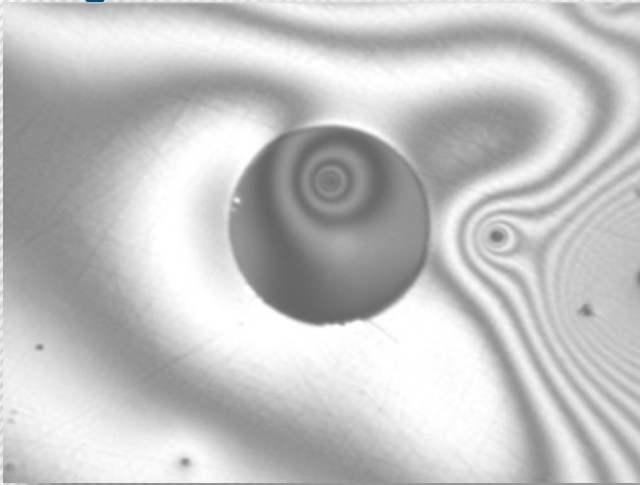


Connector B

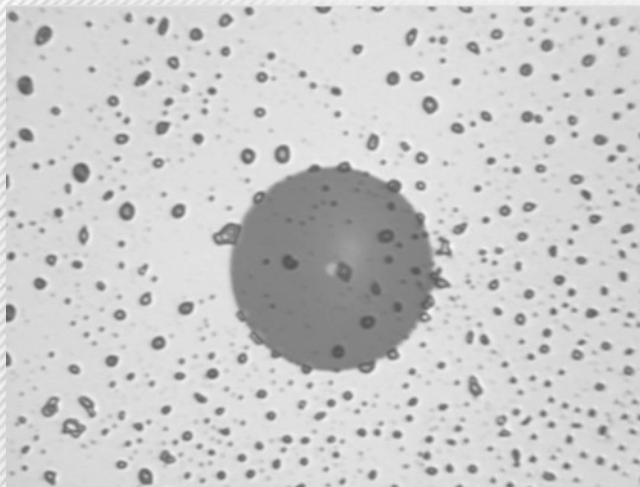


# Connector Issues

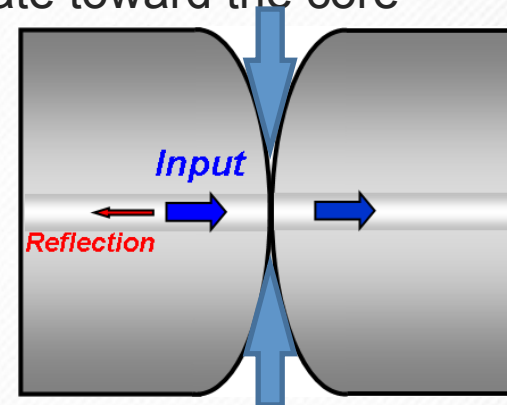
## Wet residue



After drying



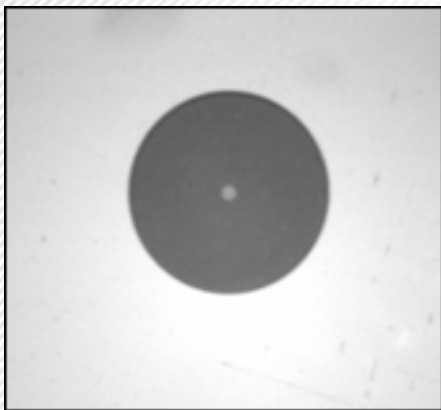
- › Most often caused by an improper cleaning technique—fibers must be dried after a wet cleaning
- › When drying, remaining dust particles will migrate toward the core



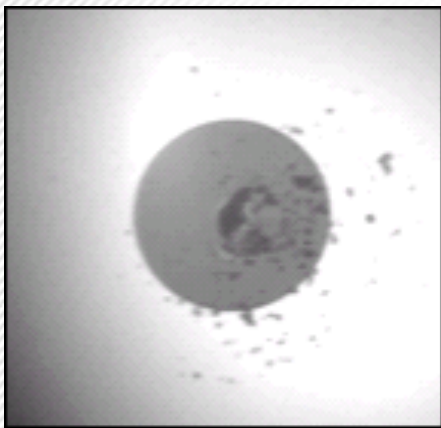
- › Proper cleaning will remove the residue
- › Liquid residues have different refractive indices than the fiber which can create problems during physical contact.
- › Residue contamination commonly interferes with back reflectance.

# Connector Issues

## High power and dirty connectors

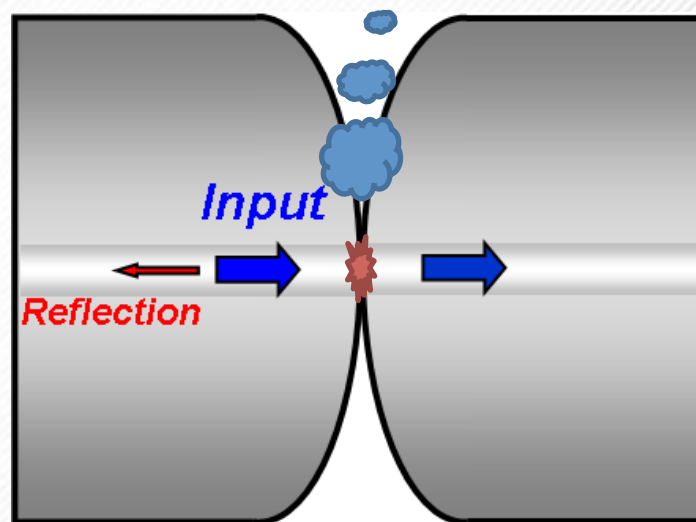


Clean



Permanently burnt –  
combined high power and dirt

- › When connecting a dirty connector into a Raman or CATV system, the density of power per surface is so high that the connector end face will burn

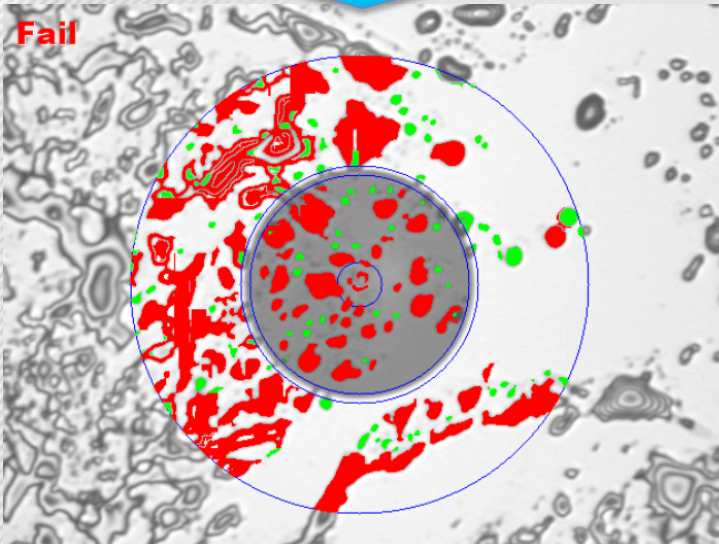
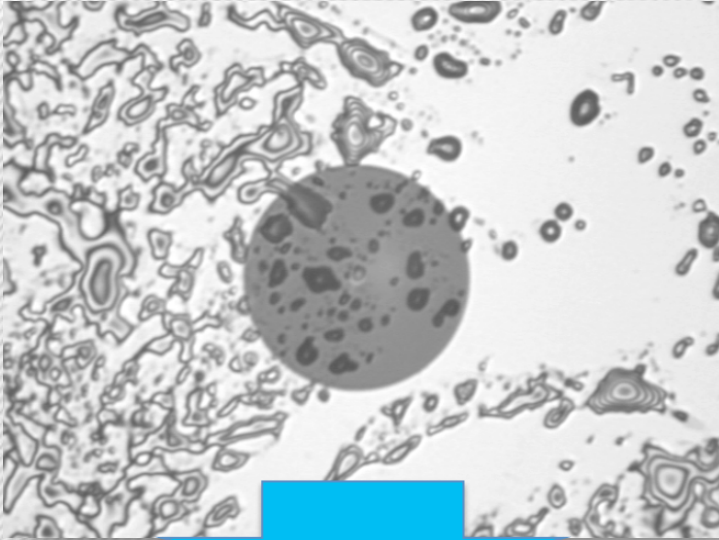


+15dBm is consider high power.



# Connector Issues

## Oil residue

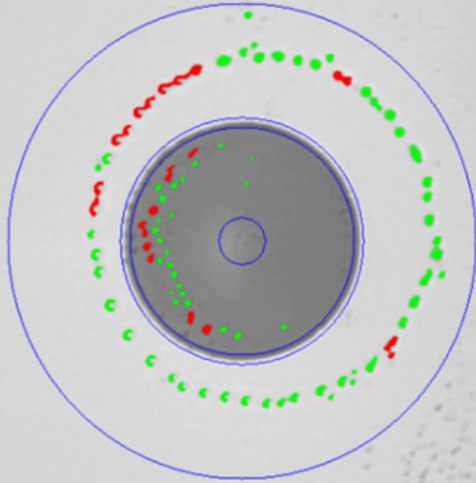


- › Most often caused by touching the fiber end—users must never touch fiber ends
- › An oil residue may act as a matching gel:
  - › May not affect IL and RL short term
  - › May trap dust and increase IL and RL with time
- › Additional truck rolls: \$\$\$
- › Proper cleaning will remove residue

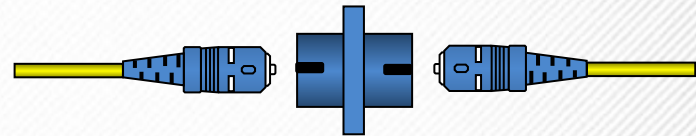
# Connector Issues

## Circular residue

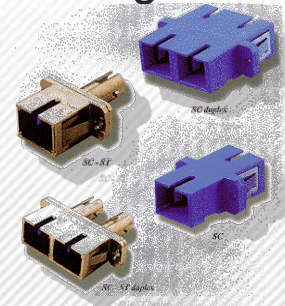
Fail



- › Most often caused by improper cleaning technique
- › Show when fiber is mated while still wet



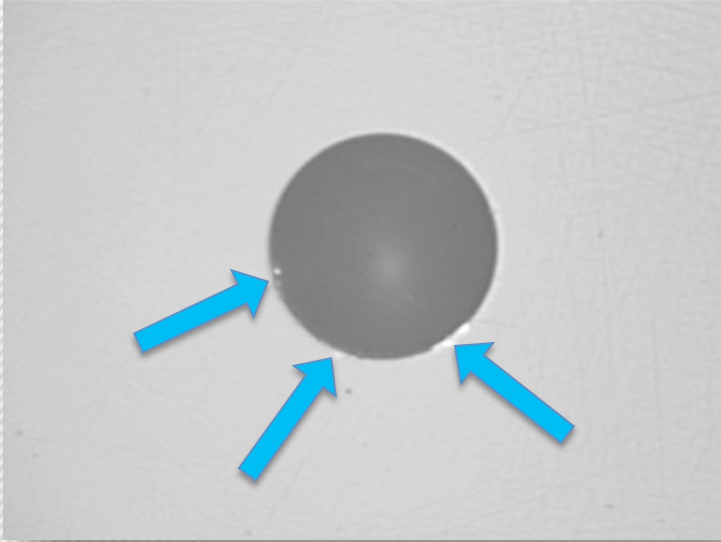
- › Typically happen within the contact area
- › Contamination will migrate from male to female fiber ends
- › Proper cleaning will remove the residue



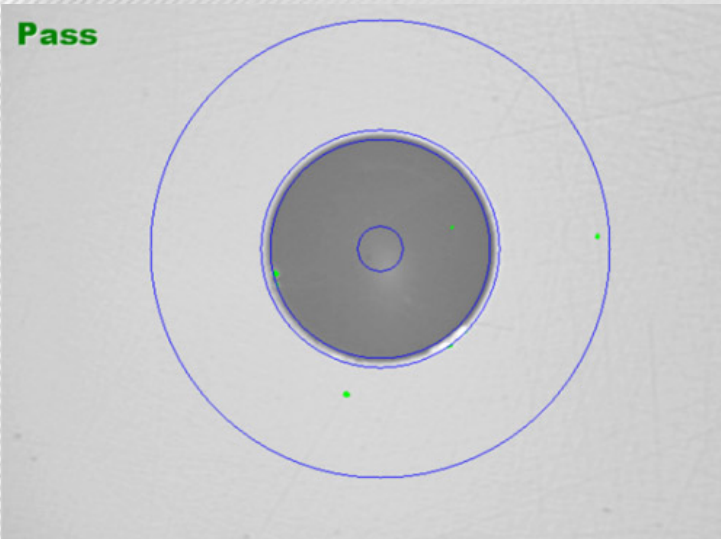


# Connector Issues

## Adhesive region defects

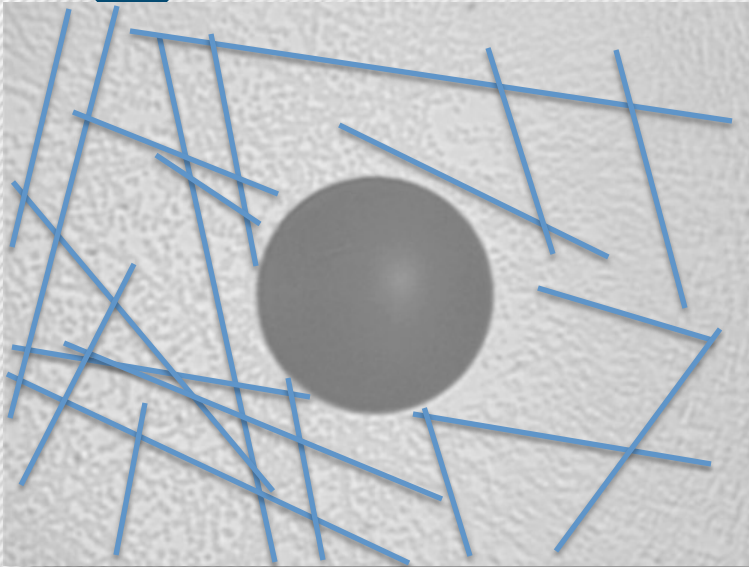


- › May originate during the manufacturing process or a mishandling
- › Epoxy and chips may show in this region
- › Are most often permanent defects
- › May show as dark or light defects
- › Are normal if size does not exceed the IEC and IPC criteria

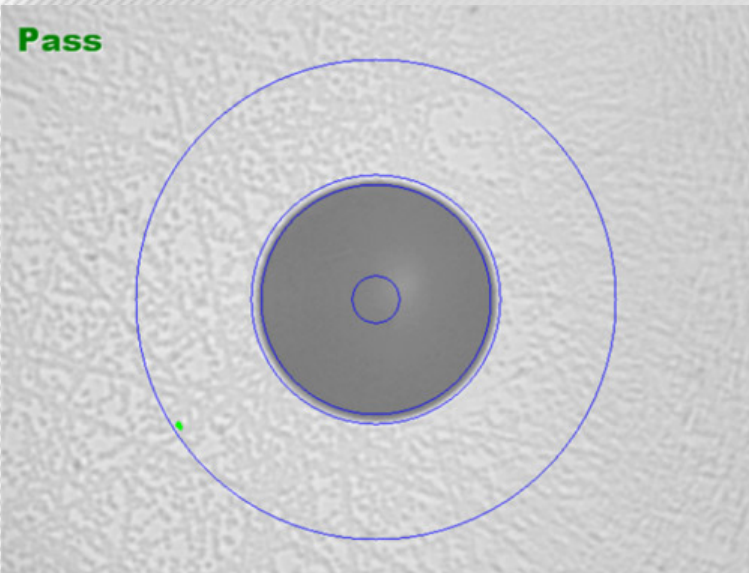


# Connector Issues

## Scratches



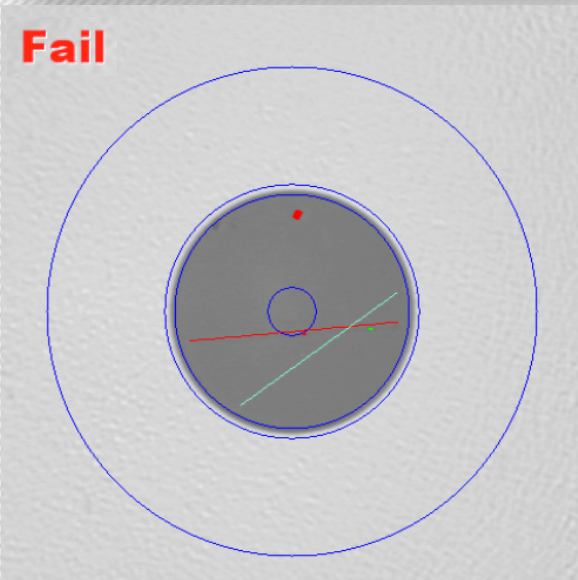
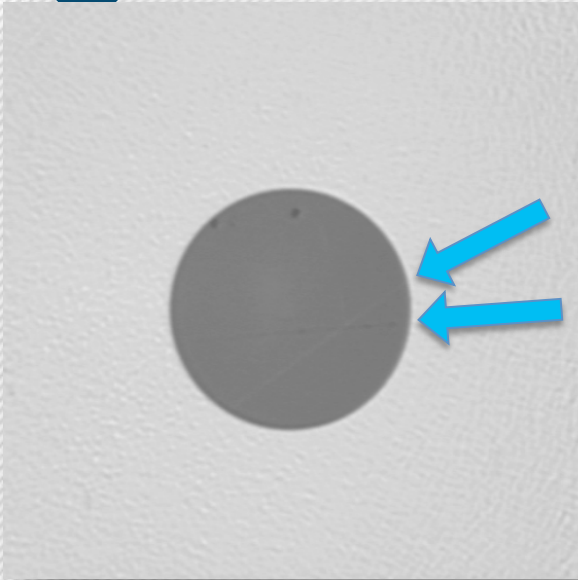
- › Are linear defects in nature
- › Are critical if appearing in the core area
- › May originate from mishandling or improper cleaning technique
- › Are permanent defects
- › May be normal if they are on the ferule surface (contact zone) depending on manufacturing techniques and connector grade
- › Cleaning connectors with shirts or trousers doesn't help...





# Connector Issues

## Scratches



- › May appear as light or dark defects
- › May be hard to see with the naked eye
- › Are critical if appearing in the core area of SM fibers

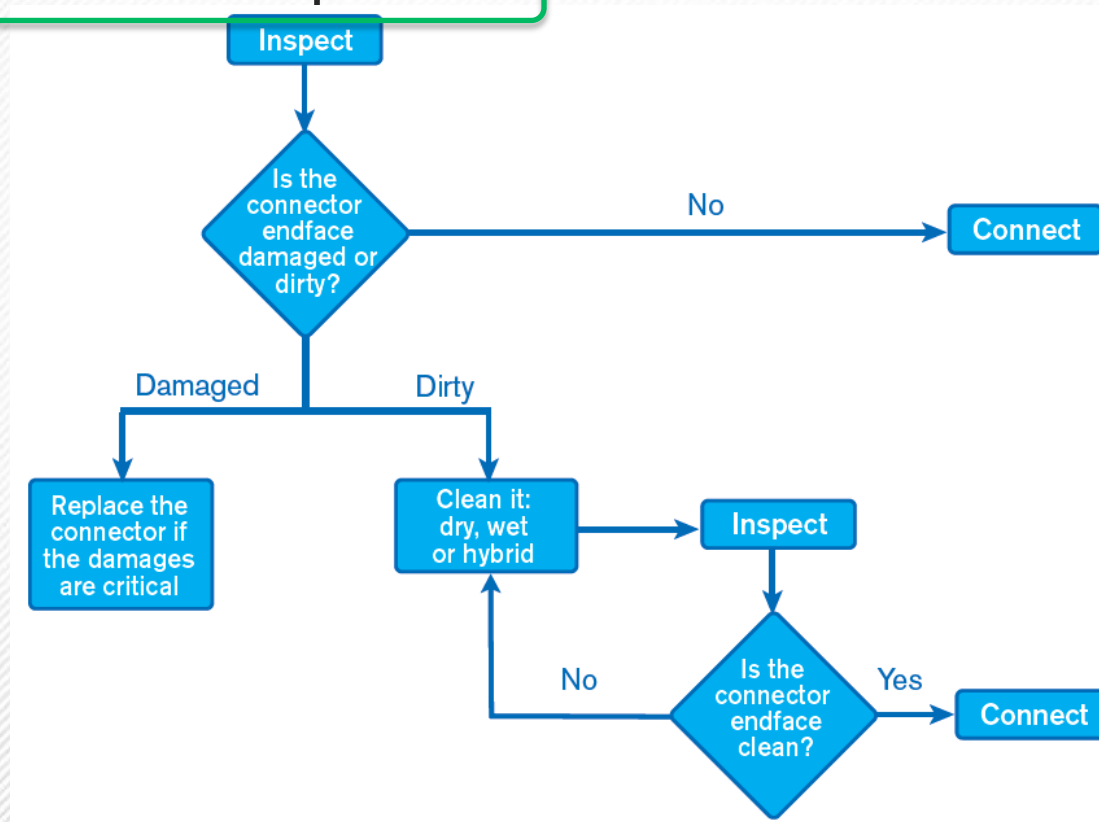
ConnectorMax				
Image	Overlay	Results	Test Configuration	Identification
<b>Configuration name:</b>		IEC-61300-3-35 Single-Mode Single-Fiber UPC Connector with ORL $\geq$ 45 dB		
<b>Connector type:</b>		(SF) Single-Fiber connector		
<b>Fiber type:</b>		(SM) Single-Mode fiber		
<b>Polishing type:</b>		(UPC) Ultra-polished physical contact		
<b>Cladding diameter:</b>		125 $\mu$ m		
Zone	Scratches		Defects	
	Criteria	Thresholds	Criteria	Thresholds
<b>A: Core</b> 0-25 $\mu$ m	0 $\mu$ m $\leq$ size $<$ $\infty$	0	0 $\mu$ m $\leq$ size $<$ $\infty$	0
<b>B: Cladding</b> 25-120 $\mu$ m	0 $\leq$ size $<$ 3 $\mu$ m	any	0 $\leq$ size $<$ 2 $\mu$ m	any
	3 $\mu$ m $\leq$ size $<$ $\infty$	0	2 $\leq$ size $<$ 5 $\mu$ m	5
			5 $\mu$ m $\leq$ size $<$ $\infty$	0
<b>C: Adhesive</b> 120-130 $\mu$ m	-	-	-	-
<b>D: Contact</b> 130-250 $\mu$ m	0 $\mu$ m $\leq$ size $<$ $\infty$	any	0 $\leq$ size $<$ 10 $\mu$ m	any
			10 $\mu$ m $\leq$ size $<$ $\infty$	0

# Best Practices

›What is the first step to any fiber testing?

~~›Cleaning~~

›Connector inspection

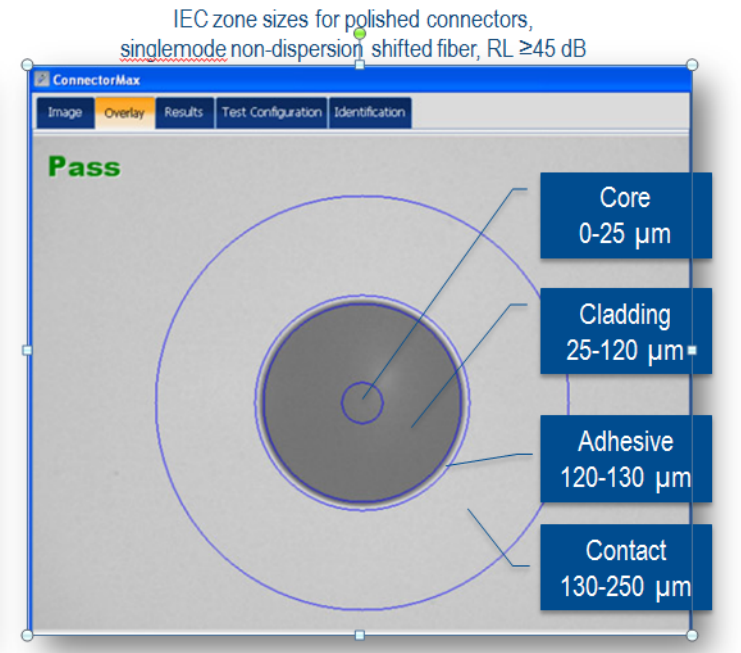
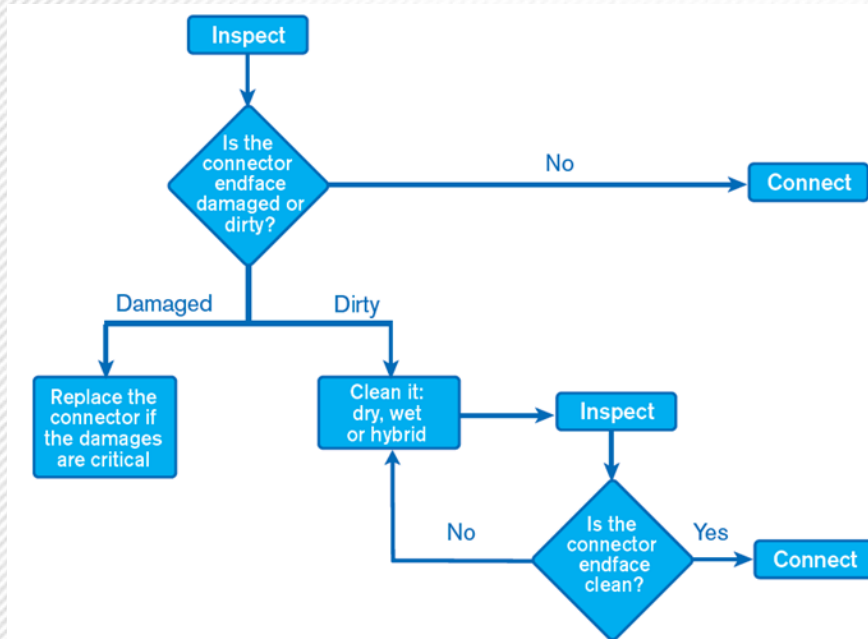




# Installation best practices

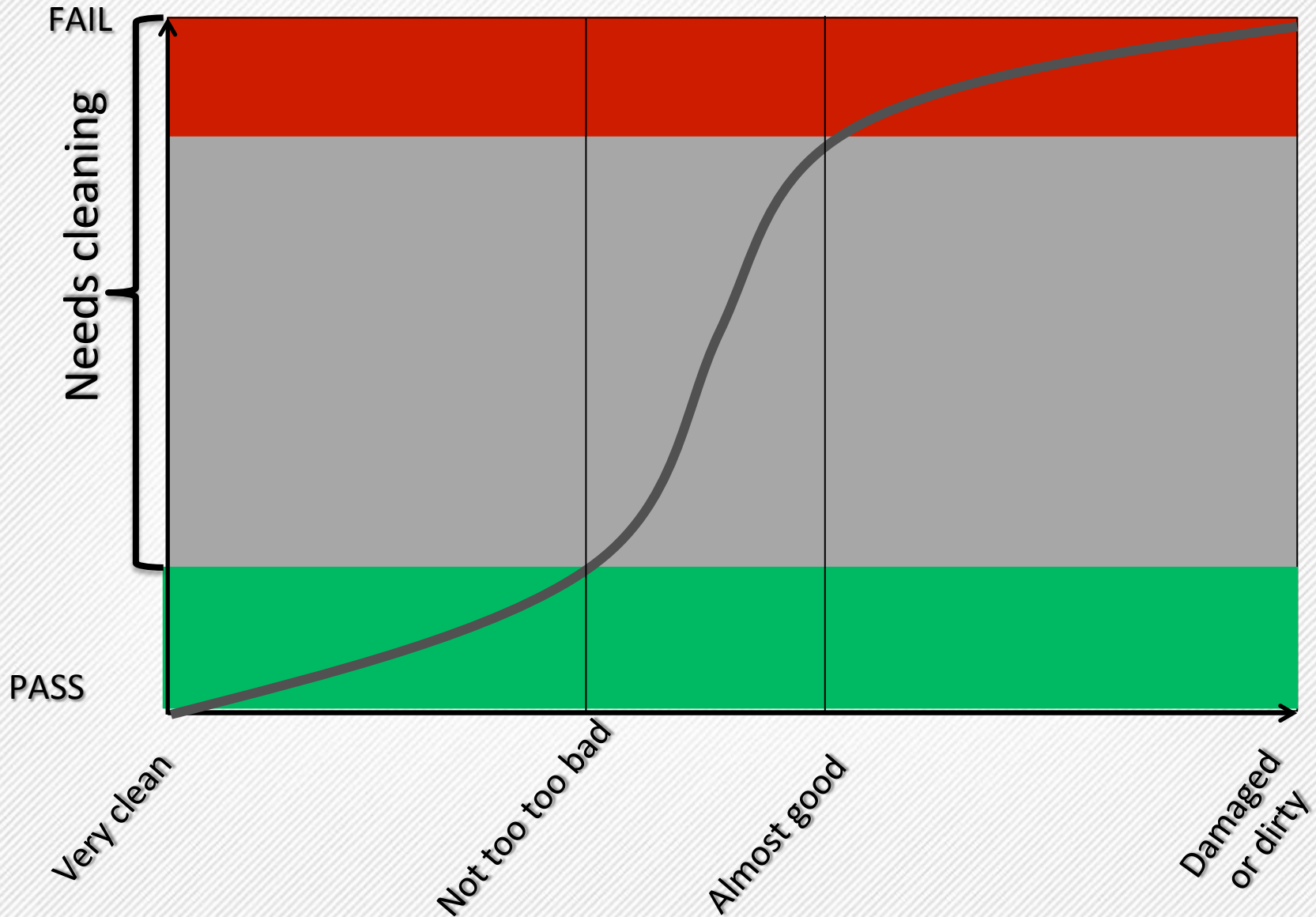
## Connector cleanliness

- A visual inspection of the end faces of connectors could be enhanced by using a software analysis based on IEC standards



# Human Cleanliness analysis

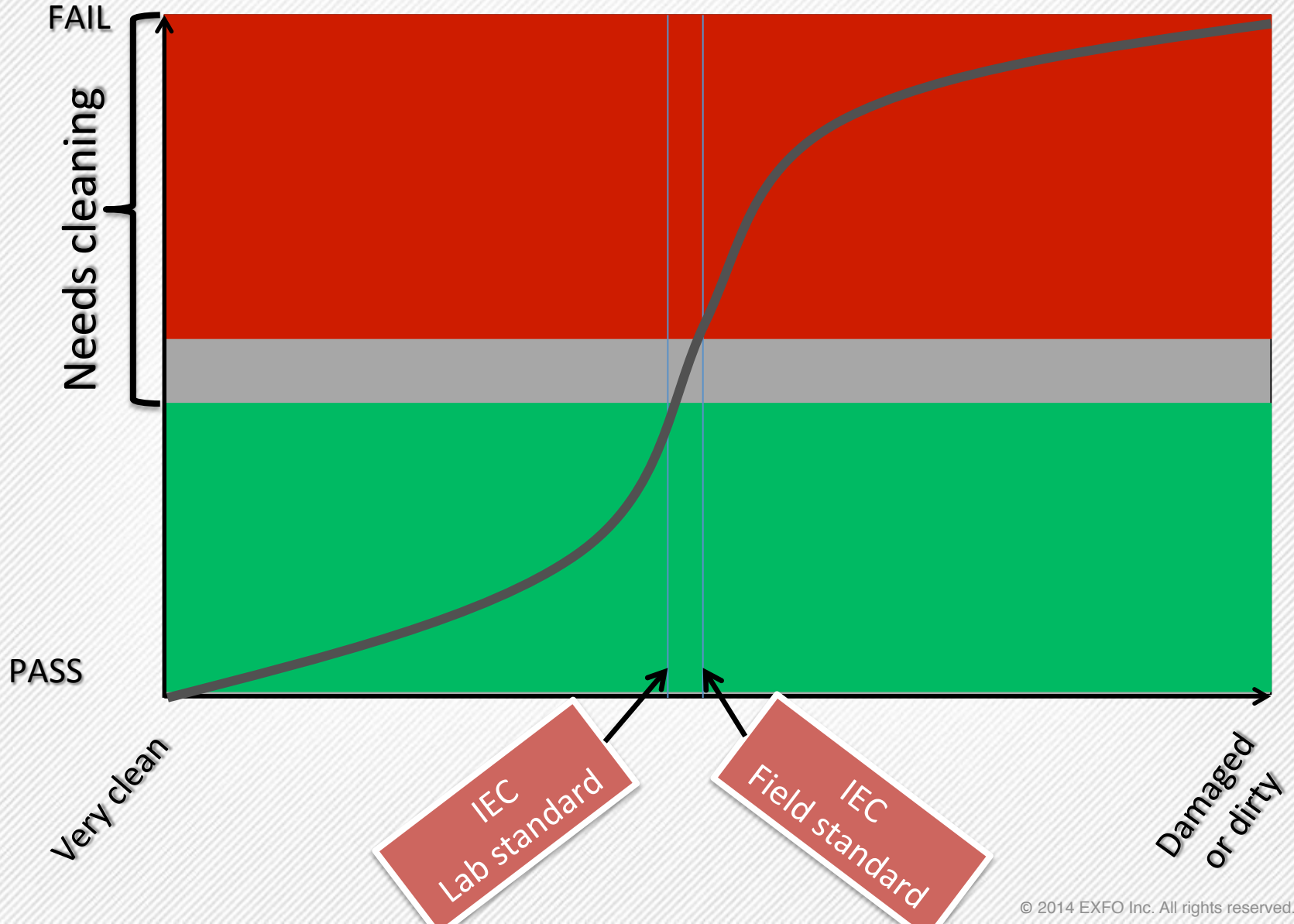
› When there is a doubt , there is no doubt, clean.....





# Software Cleanliness analysis: Manual focus

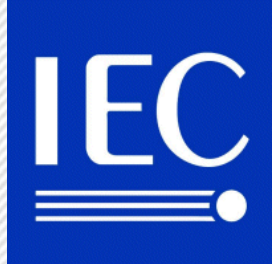
› Acceptance criterias are defined by IEC & IPC standard



# Connector Inspection Criteria

## Standards

**Criteria are defined in the following standards:**



› IEC 61300-3-35

Fiber-Optic Interconnecting Devices and Passive Components—Basic Test and Measurement Procedures

<http://webstore.iec.ch/>



› IPC 8497-1

Cleaning Methods and Contamination Assessment for Optical Assembly

<http://www.ipc.org/>



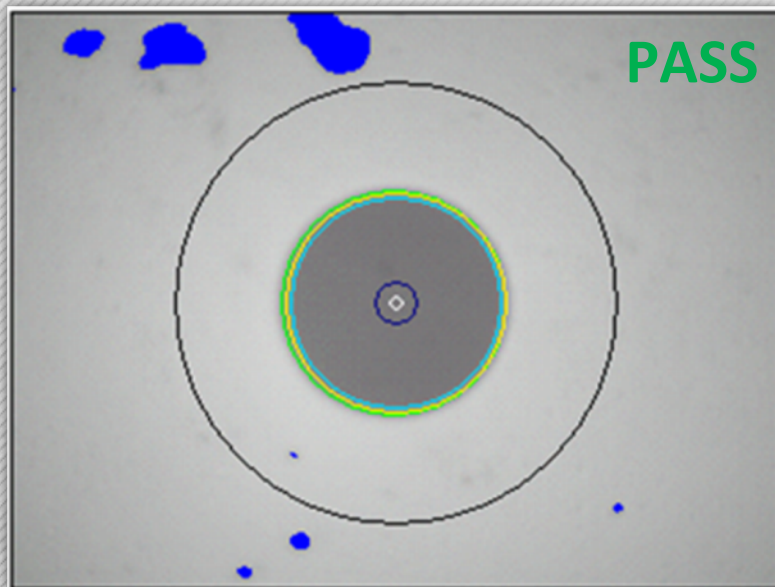
# Avoid false positives

PASS/FAIL results may be altered by a bad focus adjustment

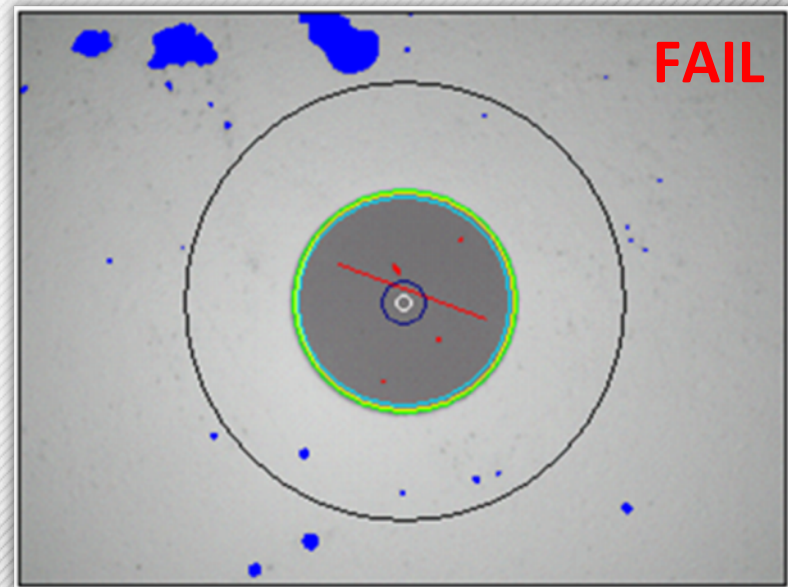
- › Focus level requirement is not stated in the IEC or IPC standard
- › An out-of-focus image can hide defects allowing failing connectors to pass the IEC analysis criteria

Example:

Pass/Fail verdict toggling on the same connector by changing slightly the focus adjustment



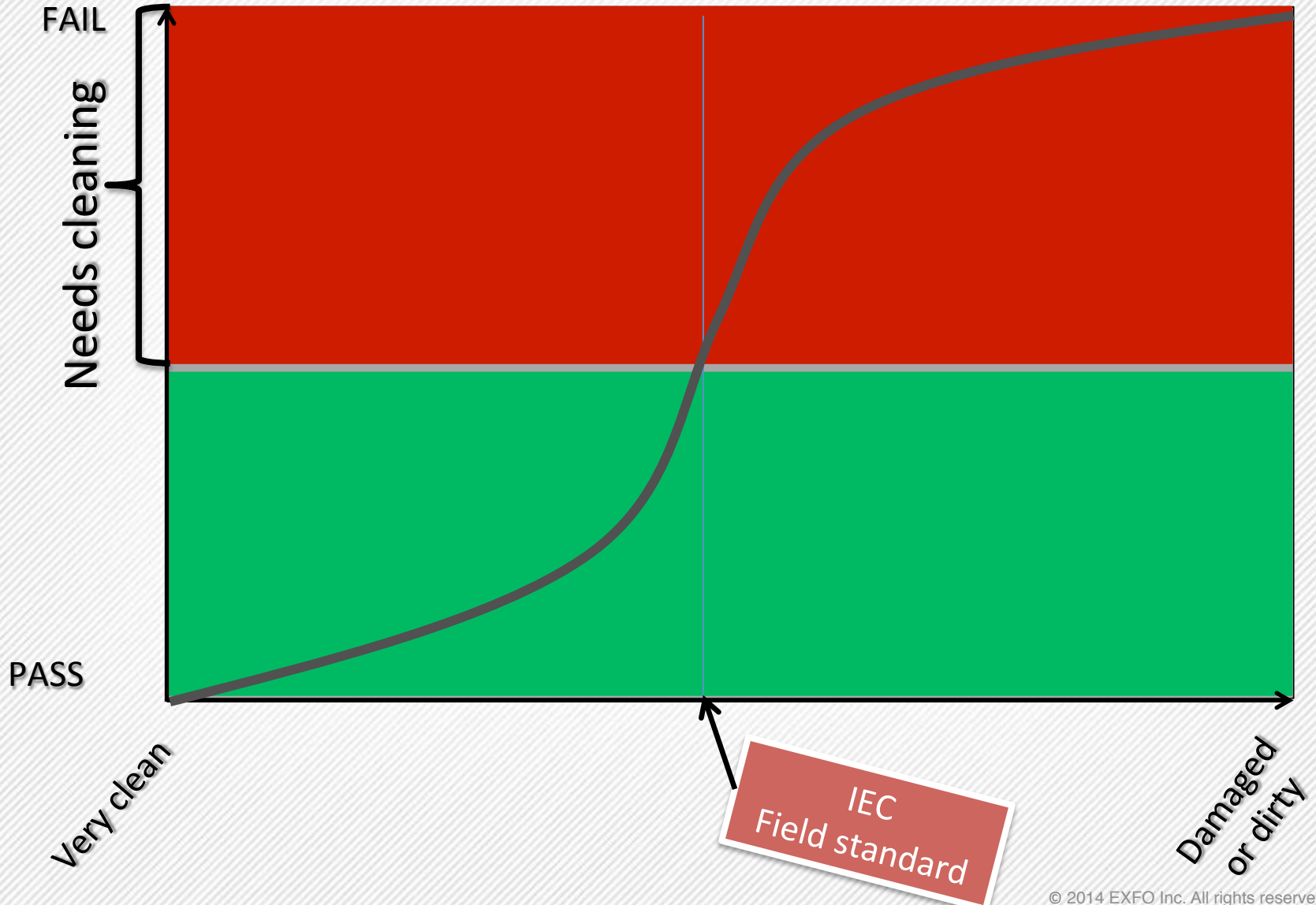
Out-of-focus image can hide critical defects delivering a « Pass » verdict



Optimized focus adjustment will ensure seeing all defects affecting performances

# Software Cleanliness analysis: Autofocus

- With automatically optimized focus the grey zone is reduced and clear decision could be made, reducing false positive/time and money..





# Poor focus = false results

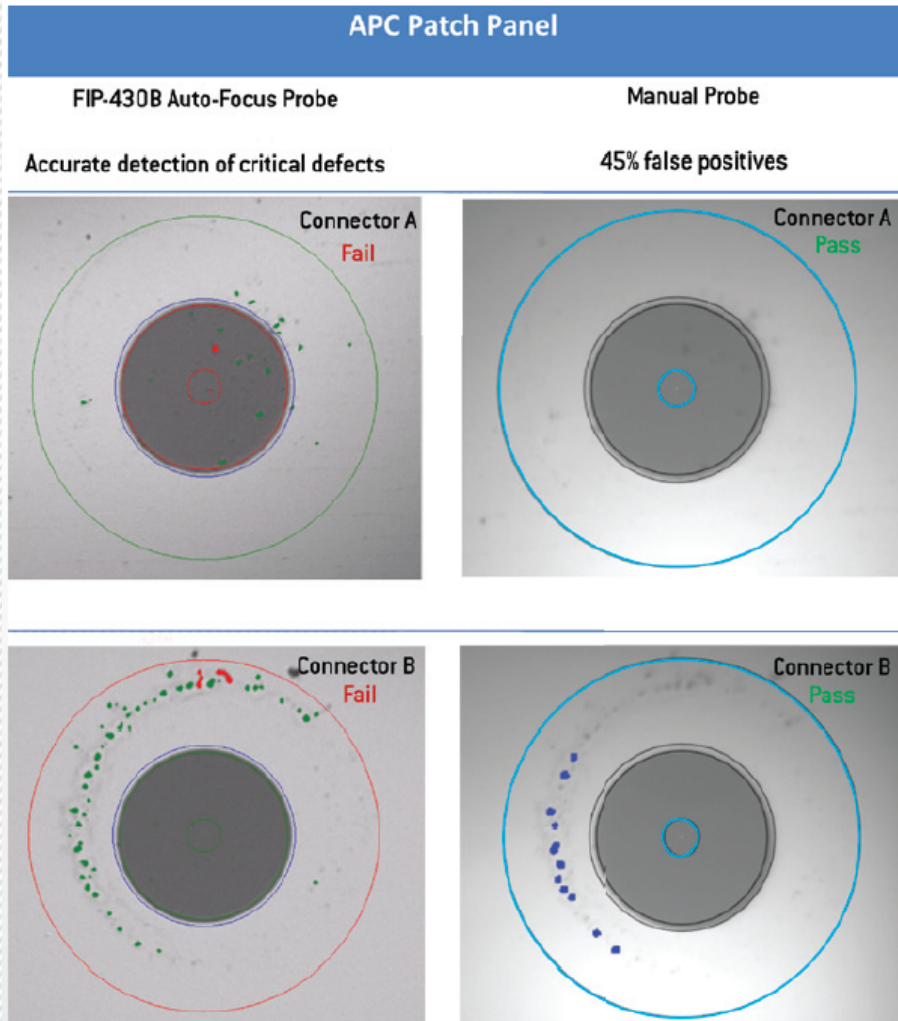


Figure 1. Manual versus automatic focusing

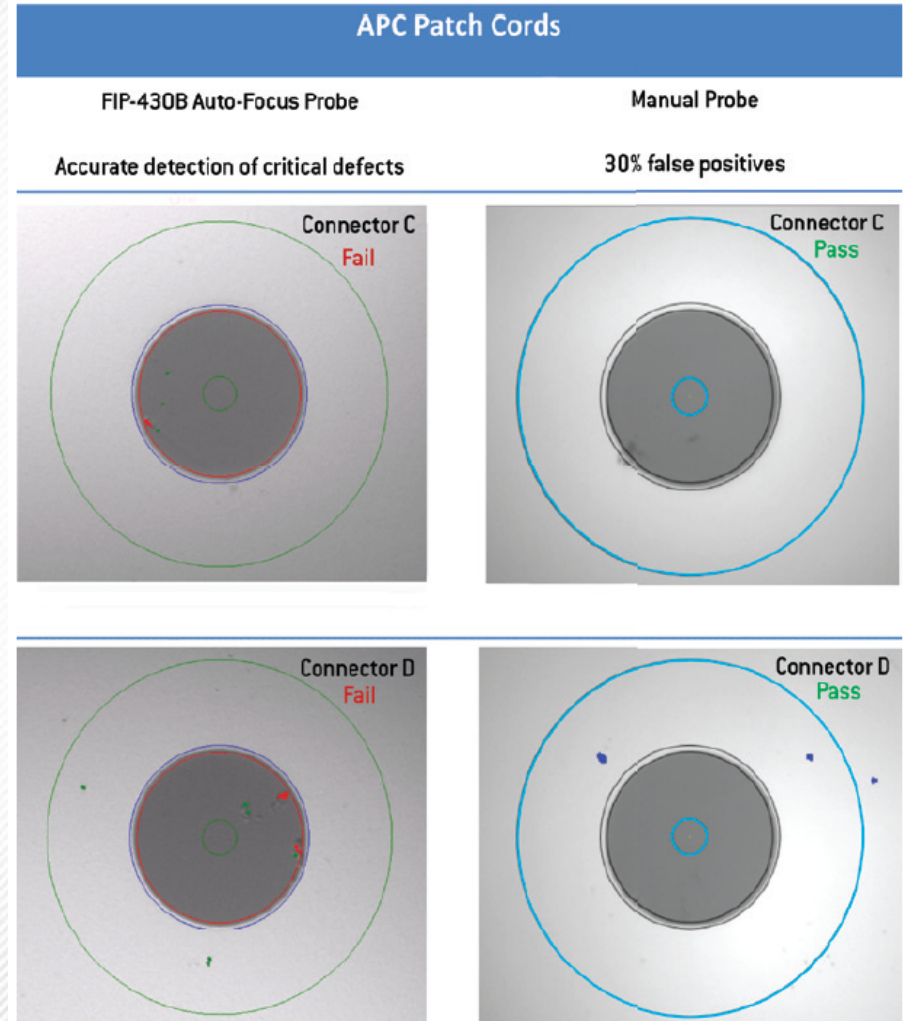


Figure 2. Manual versus automatic focusing

# IEC 61300-3-35 Connector Inspection Criteria

- › Visual requirements are defined by connector and fiber types:
  - › SM-UPC (RL >45 dB)
  - › SM-APC
  - › SM-PC (RL >26 dB)
  - › MM
  - › Multifiber

### Test Configuration Selection

Connector type

(SF) Single-Fiber Connector

(MF) Multiple-Fiber Connector

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#### Standard

IEC-61300-3-35 Multiple-Mode Single-Fiber PC Connector

IEC-61300-3-35 Single-Mode Single-Fiber APC Connector

IEC-61300-3-35 Single-Mode Single-Fiber PC Connector with ORL  $\geq 26$  dB

IEC-61300-3-35 Single-Mode Single-Fiber UPC Connector with ORL  $\geq 45$  dB

IPC-8497-1 Multiple-Mode Single-Fiber PC Connector

IPC-8497-1 Single-Mode Single-Fiber Field PC Connector

IPC-8497-1 Single-Mode Single-Fiber New PC Connector



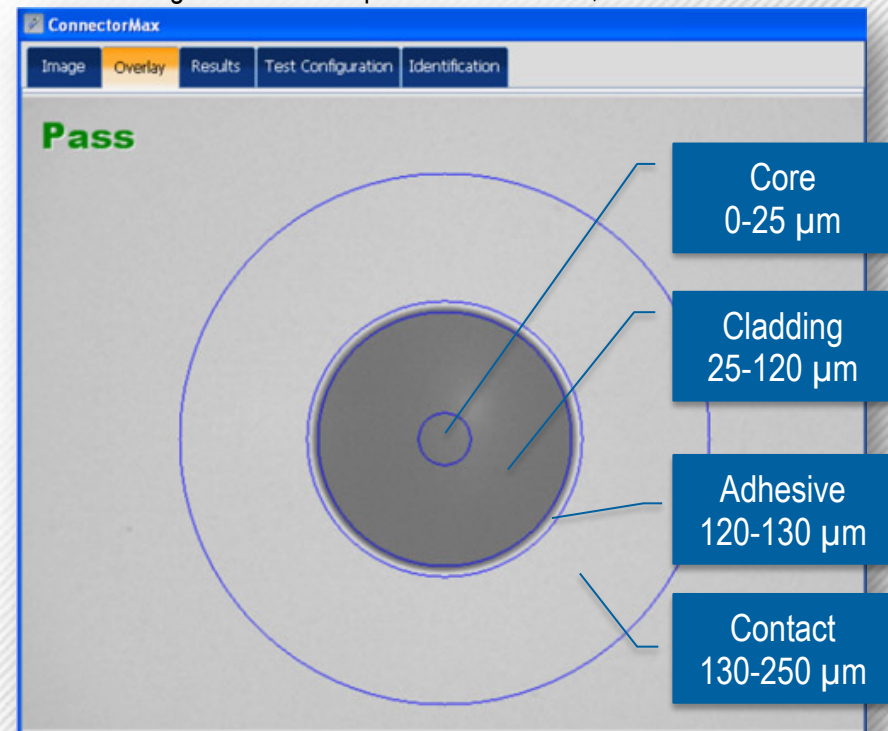
# IEC 61300-3-35 Connector Inspection Criteria

- › A connector endface is divided into multiple zones
  - › Dimensions will depend on the connector and fiber type
  - › Multimode and singlemode connectors have different sizes

IEC zone sizes for PC polished connectors, multimode fibers



IEC zone sizes for polished connectors, singlemode non-dispersion shifted fiber, RL  $\geq 45$  dB



# Cleaning

- › The IEC 61300-3-35 standard suggests an attempt to clean before rejecting a connector

- › “If the fiber fails inspection for defects, the user shall clean the fiber and repeat the inspection process.”
- › Some organizations standardize using different approaches, such as performing up to three cleaning attempts before rejecting

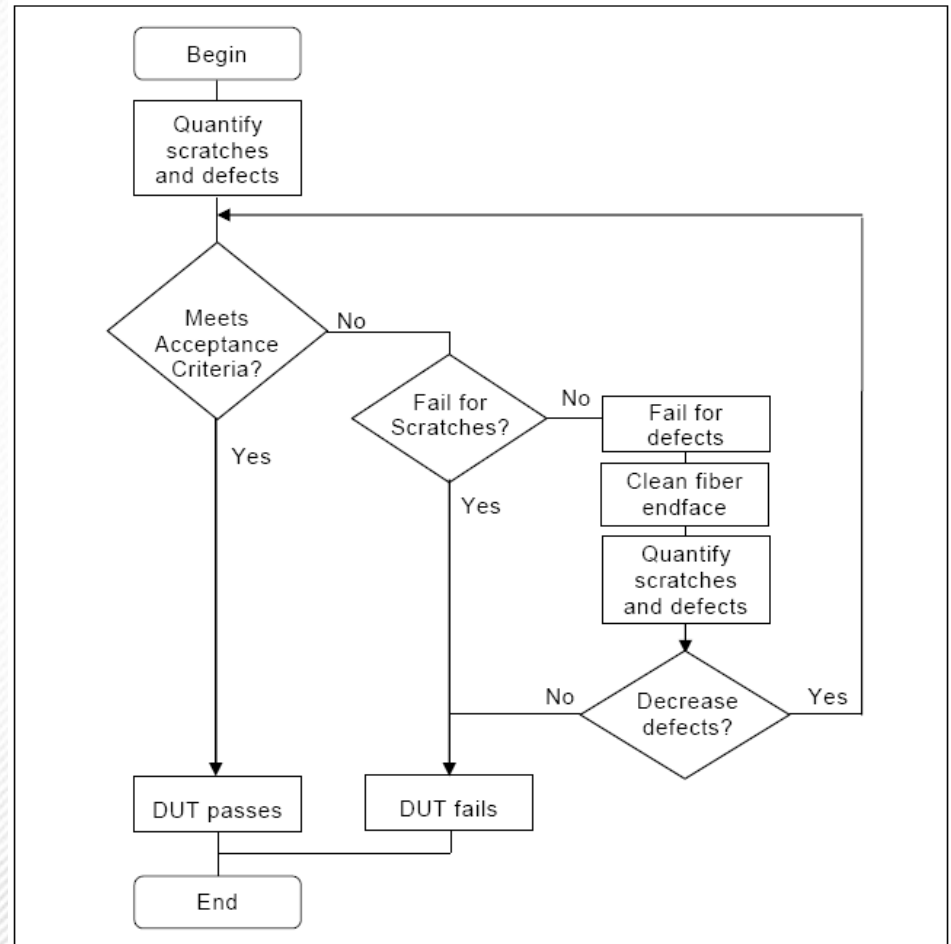


Figure 1 – Inspection procedure flow



# Cleaning

## Dry method

- › An efficient technique for removing light contaminants
- › Often considered the technique of choice in a controlled manufacturing environment where speed and ease of use are important factors

Advantages	Disadvantages
Convenience of readily available tools	Can possibly create electrostatic charges
Fast and easy	Not effective in removing all contaminant types

## Example of dry cleaning supplies:

- › Specialized lint free wipes and swabs
- › Mechanic cleaning devices





# STATIC ELECTRICITY

"Yeah, really funny... rub me on the carpet and then put me in the shipping box... You will pay for this!"



# Cleaning

## Wet method

- › The main purpose of using the wet-solvent approach is to raise dust and contaminants from the connector's endface to avoid scratching the connector
- › The most widely-known solvent in the industry is the 99.9% isopropyl alcohol (IPA), which removes most contaminants

Advantages	Disadvantages
Can dissolve complex soils and contaminants	Can leave residue on the ferrule when too much solvent is used and not properly dried
Eliminates the accumulation of electrostatic discharge on the ferrule	Solvent choice can be confusing with issues of performance and EH&S

## Example of wet cleaning supplies:

- › Pre-saturated swabs



# Cleaning

## Combination method (hybrid)

- › Combination cleaning is a mix of the wet and dry cleaning methods
- › The first step in hybrid cleaning is to clean the connector end-face with a solvent and to dry any remaining residue with either a wipe or a swab

Advantages	Disadvantages
Cleans all soil types	Requires multiple products
Reduces potential static field soil accumulation	
Automatically dries moisture and solvent used in the cleaning process	
Captures soil in wiping material as an integrated aspect of cleaning procedure	
Not expensive	

Example of combination cleaning supplies:

- › Specialized wipes and solvents





# Dry Wipes

Fabric-based and paper wipes that provide a mechanical action to absorb residues and trap dust particulates

Examples include: Tissues, field cards, etc.

## ADVANTAGES:

- › Cleans end face while disconnected from mating adapter
- › Common technique in the industry
- › Allows both dry & wet cleaning

## DISADVANTAGES:

- › Cannot clean end face through mating adapter
- › Untrained operators can damage fiber end face
- › Must be protected from contamination until just prior to use
- › Some wipes can deposit fabric on the end face (self-contamination)



# Cleaning Cassettes

Relatively mature cleaning technology using a reel of specialty fabric

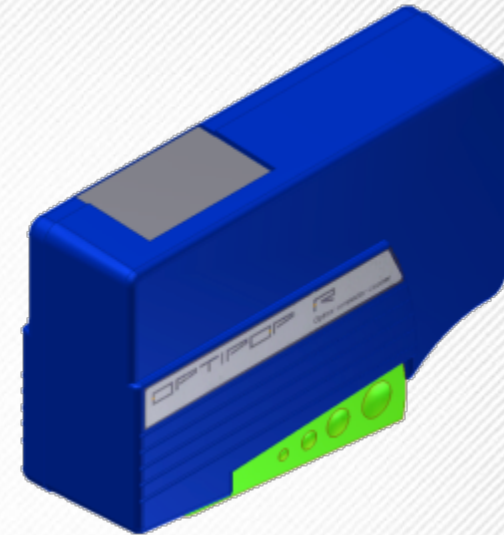
Examples include: OPTIPOP, CLETOP, etc.

## ADVANTAGES:

- > Low cost per clean
- > Faster cleaning times
- > Better consistency in cleaning performance
- > Refill packs for even lower cost per clean

## DISADVANTAGES:

- > Cannot clean end face through mating adapter





# Sticks & Swabs

Swabs may be beneficial for cleaning connector end faces installed in adapters

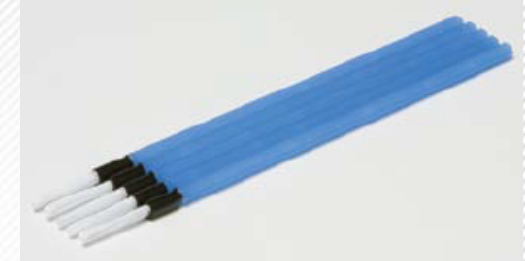
Examples include: Sticks, swabs, etc.

## ADVANTAGES:

- › Cleans the ferrule end face while installed in mating adapters
- › Allows cleaning of some specialty connectors without requiring disassembly of the connectors

## DISADVANTAGES:

- › Cannot clean end face while disconnected from mating adapter
- › Can be more costly than other methods
- › Limited cleaning effectiveness due to the physical constraints of the adapter
- › Some swabs can deposit fabric on the end face (self-contamination)



# Mechanical Cleaning Tools

Relatively new technology that advances a cleaning cloth across the end face in a controlled fashion

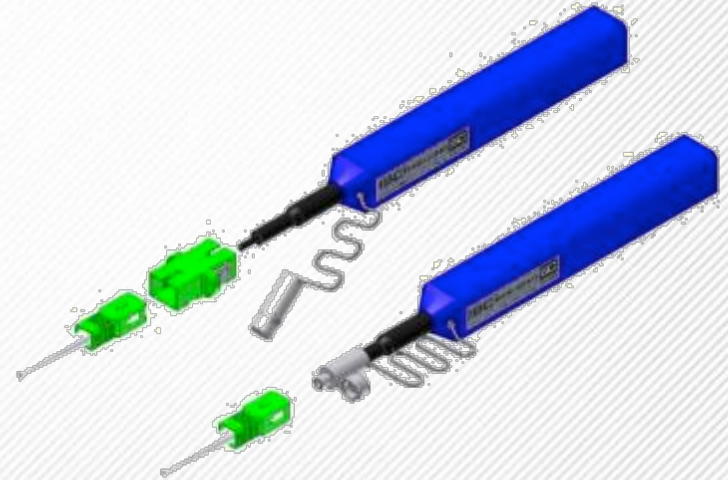
Examples include: IBC™ Brand Cleaning tools

## ADVANTAGES:

- › Cleans end faces in both mated (with adapter) and unmated conditions
- › Simple, One-hand operation
- › Faster cleaning times
- › Consistent cleaning performance
- › Custom tools can be developed for specialty connectors

## DISADVANTAGES:

- › Some tools have limited cleaning region
- › Some tools do not have a good method for keeping material on the track





# Mechanical Cleaning Tools – Speciality Connectors

Same IBC™ Brand Cleaning technology now available for multiple industry connector-types

## ADVANTAGES:

- › Available for Telecom, Military, Aerospace, FTTX, & more
- › Cleans end faces in both mated (with adapter) and unmated conditions
- › Simple, One-hand operation
- › Faster cleaning times
- › Consistent cleaning performance
- › Custom tools can be developed for specialty connectors

## DISADVANTAGES:

- › Some tools have limited cleaning region
- › Some tools do not have a good method for keeping material on the track



# Do not plug and pray!

Use the right tools, do it right!



Inspect clean verify connect